APPENDIX A

Part B of the Waste Treatment Industry Questionnaire and Facility Information Sheet Form for NOA Notification

APPENDIX B

Waste Generation by SIC Code

TABLE B-1. WASTE GENERATION BY SIC CODE, 1995

SIC	Total Transfers to Recycling	Total Transfers to Treatment
343		18,225
347		10
1446		250
2011		5,950
2013	12,814	
2015	250	-
2020		132,700
2022		21,500
2024	1,330	23,913
2026	38,937	33,800
2032		18,330
2033	14,414	15,771
2037		12,534
2038	1,352	
2043		93,267
2046	77,668	1,064
2048	25,556	2,375
2066		91,733
2075	164,287	
2076	13,280	
2077	9,000	
2079	2,658,513	181,800
2082	4,400	69
2086	14,305	750
2087	500	15,033
2096		8
2099	46,689	71,627
2111	43,158	1
2121		510
2141		10

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
2221	89,643	4,003
2231	614	454
2252	7,500	
2257		45,327
2259		299
2261		1,370
2262		9,478
2269	326,000	36,059
2271		5,693
2273	240	25,871
2295	309,541	484,096
2296	3,306	5,024
2297	65,523	3,083
2298		5
2299		7,277
2329	217	225
2353	2,554	2,220
2389		1,250
2390	250	55,600
2393		750
2399		5
2421		1,650
2426	7,681	
2430	755	250
2431	202,681	16,426
2434	225,840	133,963
2435		12,550
2439	250	
2451	6,263	250
2491	100,868	336,851

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
2492		85
2493	16,229	1,989
2499	177,743	23,751
2500	3,312	
2511	1,542,889	110,014
2512	10,366	25,261
2514	26,250	2,240
2517	8,747	2,250
2519	4,986	
2521	75,239	300,326
2522	3,161,164	22,397
2530	250	
2531	1,195,310	114,626
2541	10,082	750
2542	256,748	220,598
2565		100
2579		500
2591	89,594	1,976
2599	244,776	2,991
2611	880	7,533,628
2621	3,522,972	341,958
2631	265	30,264
2641	142,134	63,011
2651	29,030	40,090
2653	17,749	
2655	888	985
2656	861	3,294
2657	66,055	22,294
2671	401,645	383,389
2672	848,621	849,200

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
2673	14,274	22,200
2677		4,900
2679	119,000	1,357
2700	18,950	18,595
2732	1,553	13,764
2751	1,652	2,986
2752	2,214,572	88,527
2754	2,656,857	177,931
2759	108,360	30,976
2761		10,062
2771	3,265	5
2782	8,116	
2793		2,958
2796	577,294	107,791
2800	17,765	1,502
2812	15,617,381	2,088,582
2813	122,057	313,530
2816	884,051	721,850
2819	8,459,039	8,175,239
2821	78,202,133	29,361,314
2822	8,097,634	5,207,745
2823	79,025	1,166,588
2824	42,424,350	139,320
2830		1,973
2831		51
2833	5,657,556	10,444,156
2834	12,118,681	14,784,821
2835	7,496	121,609
2836		21,880
2840		5,580

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
2841	518,938	94,734
2842	16,490	315,242
2843	219,215	568,083
2844	5,188	23,167
2850	685,140	44,421
2851	32,401,466	6,222,012
2861		20,300
2865	7,226,573	18,195,149
2869	32,094,363	37,359,370
2873	1,014,225	2,000
2875	1,500	15,072
2879	4,570,376	7,631,528
2880		84,000
2890	13,568	
2891	580,852	1,723,779
2892	699,134	149,822
2893	967,330	457,800
2899	1,296,941	3,251,105
2911	5,847,506	2,871,698
2952	9,716	1,029
2977		7,220
2992	17,911,102	150,357
2999	56,138	70,750
3000		140,330
3011	1,332,699	247,150
3021	16,117	3,613
3041	56,800	8,200
3050		1,101
3052	1,837,134	65,167
3053	212,672	170,103

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
3061	149,490	64,085
3066	22,400	
3069	801,365	361,246
3070	25,345	2,582
3079	192,573	26,462
3081	8,600,889	1,762,040
3082	82,487	15,945
3083	669,073	166,119
3084	23,310	11,480
3085	39,750	
3086	1,212,659	849,028
3087	81,815	119,902
3088	41,356	8,035
3089	5,219,941	592,758
3111	191,268	144
3131	15,836	1,292
3142		500
3143	2,206	4,158
3149	7,487	500
3174	2	92
3179	233,750	
3211	35,020	28,727
3221	327,753	54,240
3229	1,562,374	463,625
3231	316,258	77,508
3237	766	
3241	193,744	136,393
3251		10
3253	115,858	
3255		1,500

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
3261	211,400	58
3262	40,017	69,451
3264	84,575	3,644
3269	3,359	1,000
3272	122,976	250
3274	250	
3281	10,583	
3291	204,585	289,295
3292	289,000	2,501
3293	1,300	
3295	1,883,231	937,332
3296	239,964	13,334
3297	49,444	1,095
3299		229,218
3300	2,145	11,676
3312	329,290,744	17,669,827
3313	730,866	51,388
3315	7,464,555	1,305,611
3316	10,955,839	2,043,387
3317	21,167,079	3,528,872
3320	2,209	374
3321	10,562,473	371,507
3322	3,602,317	105,427
3324	4,406,223	31,129
3325	6,315,726	551,452
3331	24,734,074	4,822,340
3334	2,980,175	20,248
3339	13,600,560	72,988
3340	1,435,064	
3341	36,343,977	3,378,814

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
3351	67,105,217	235,387
3353	6,318,418	226,709
3354	4,651,996	57,404
3355	45,687	83,203
3356	15,070,951	457,617
3357	179,304,894	529,176
3360	160,427	-
3361	1,918,433	12,757
3362	3,184,852	15,606
3363	9,956,634	30,252
3364	2,202,706	7,500
3365	4,079,204	6,089
3366	6,448,566	39,421
3369	8,954,061	117,121
3380	43,058	
3398	426,456	207,300
3399	3,883,529	48,887
3400	479,327	
3411	12,308,553	148,100
3412	209,856	220,310
3417		22,514
3421	265,101	9,375
3423	454,421	117,176
3425	327,713	
3428	22,900	
3429	8,255,968	312,313
3430	33,500	
3431	359,829	181,137
3432	36,439,006	167,774
3433	898,402	23,718

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
3440	88,000	
3441	1,679,592	106,262
3442	124,061	76,297
3443	5,378,860	204,065
3444	1,958,765	268,388
3446	467,728	26,426
3448	93,177	32,022
3449	991,175	4,015
3450	36,881	46,023
3451	44,460,648	37,946
3452	879,791	34,575
3460	101,269	
3462	25,213,311	342,335
3463	1,947,844	215,188
3465	21,936,104	173,676
3468	1,275,503	320
3469	17,469,642	269,274
3470		2,013
3471	36,312,074	3,022,958
3479	27,759,664	1,607,926
3482	9,077,583	94,114
3483	245,500	3,505
3484	538,681	36,330
3489	142,984	64,257
3490	224,869	5,681
3491	5,630,194	3,576
3492	3,589,521	34,047
3493	79,555	18,089
3494	25,683,373	97,631
3495	51,399	5,296

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
3496	4,804,335	400,156
3497	7,942,154	378,345
3498	3,864,159	451,761
3499	28,801,072	716,689
3500	5,851	
3511	2,794,564	154,194
3519	3,349,987	193,274
3523	2,667,977	30,941
3524	81,082	750
3531	1,927,996	108,996
3532	785,714	10,958
3533	1,030,917	795
3534	377,701	
3535	627,680	3,975
3536	438,577	3,002
3537	1,127,241	1,964
3541	695,623	27,594
3542	287,008	9,400
3544	3,969,636	50,971
3545	549,231	95,742
3546	386,398	50,120
3547	97,955	2
3548	1,685,401	32,612
3549	1,100	
3550		4,060
3551	36,926	-
3552	20,380	
3553	12,024	
3554	1,748,320	21,507
3555	277,293	53,288

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
3556	1,498,811	10,406
3559	4,663,816	84,756
3561	4,549,118	6,689
3562	5,086,542	13,122
3563	602,147	2,419
3564	118,001	650
3565	48,335	
3566	756,630	750
3567	299,793	
3568	3,148,051	56,237
3569	1,402,997	97,425
3571	565,925	36,041
3572	7,100	2,600
3573	18,270	5
3574		154,366
3577	35,545	3,800
3579	54,121	16,607
3580	74,410	
3581	1,745	250
3582	1,305,518	2,515
3583	20,052	
3585	15,240,370	77,603
3586	26,655	
3589	299,809	28
3592	2,619,265	122,781
3593	265,540	76,188
3594	2,392,749	15,249
3596	13,091	
3599	768,298	37,699
3600	7,810	

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
3610	250	14,073
3612	6,867,955	582,224
3613	9,691,397	26,722
3619	1,370	
3621	15,075,742	64,555
3622	55,622	
3623	129,562	
3624	1,763,129	5,175
3625	915,833	13,950
3629	1,606,976	17,476
3631	1,053,180	3,350
3632	1,454,214	16,087
3633	784,485	2,899
3634	238,030	
3635	49,466	
3639	684,728	7,822
3641	1,393,941	248,226
3643	7,051,631	47,062
3644	1,135,232	31,933
3645	44,465	5,050
3646	587,328	17,299
3647	107,914	134,077
3648	1,759,875	1,250
3651	1,810,188	17,815
3652	59,161	6,354
3661	2,991,074	13,006
3662	322,000	
3663	6,136,001	7,947
3669	1,926,175	43,572
3670	40,000	

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
3671	5,446,597	629,263
3672	26,622,464	1,483,939
3674	1,054,550	821,120
3675	2,804,726	1,474,200
3676	240,776	14,224
3677	237,736	11,901
3678	6,912,007	4,722
3679	6,400,800	165,511
3691	260,725,363	31,951
3692	3,698,528	138,514
3694	6,799,919	14,472
3695	2,713,816	281,006
3699	2,438,326	9,430
3700	186,706	
3710	1,406,634	1,528
3711	42,813,612	1,277,849
3713	4,029,660	139,190
3714	101,160,421	1,635,088
3715	4,634,727	47,583
3716	126,469	2,750
3720	2,900	
3721	1,322,085	477,964
3724	8,233,990	732,439
3728	4,790,125	343,538
3731	3,057,662	147,354
3732	163,277	20,982
3743	4,379,805	174,014
3744		4,000
3751	3,741,285	20,491
3761	66,505	24,639

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
3764	486,745	54,961
3769	17,100	6,283
3771	941	
3792	9,870	27,853
3795	129,734	82,479
3799	186,442	33,984
3812	33,025	66,023
3821	169,695	159,109
3822	8,803,870	92,683
3823	367,421	17,098
3824	1,831,529	595
3825	492,339	6,840
3826	48,250	103,861
3827	11,989	5,037
3829	89,562	1,962
3832	4,200	18,000
3841	1,032,905	256,305
3842	1,044,458	15,495
3843	143,220	1,322
3844	133,082	29,699
3845	106,201	10,570
3851	296,366	35,376
3861	6,565,945	3,021,443
3873		5,038
3910		2,168
3911	60,165	4,756
3914	2,654,974	32,047
3915	266,634	
3931	193,431	39,228
3940	2,602,832	11,957
3944	23,500	2,600

(continued)

TABLE B-1. WASTE GENERATION BY SIC CODE (CONTINUED)

SIC	Total Transfers to Recycling	Total Transfers to Treatment
3949	750,814	120,246
3951	219,891	4,820
3952	211,334	
3953	6,890	13,677
3955	36,000	124,109
3961	54,653	1,595
3964	509,153	250
3965	5,584,002	61,619
3991	3,800	461
3993	898,121	40,886
3995	1,684,185	1,020
3996	64,652	13,471
3999	4,743,208	850,594
4396		2,250
4911	22	
4925		1,000
4953		27,100
5047	345,219	
5063	88,700	
5091	750	
5169	224,287	202,547
5171	858	340
5172		750
7216	6,400	
7389	514,413	215,243
7699	32,640	9,634
8731	3,000	139,339
8733	6,807	4,511
8734		39,778
9661	29,469	12,075
9711	2,041,238	893,292
9999	64,432	1,021

Source: Toxics Release Inventory, 1995.

APPENDIX C

SIC Code Definitions

APPENDIX D

Detailed Description of the Economic Impact Analysis Model

This appendix summarizes in greater detail the economic impact methodology used to assess impacts of the proposed effluent limitations guidelines and standards on commercial CWT facilities. The Agency developed a partial-equilibrium market model that simulates facility responses to the regulatory costs, resulting in changes in market supply, price, quantity, facility revenues, costs, and employment.

D.1 REGIONAL MARKETS FOR CWT SERVICES

Because wastewater is heavy, bulky, and therefore costly to transport, the markets for CWT services are fairly localized. EPA defined six geographical regions across the continental U.S., within which CWT services are provided. These regions, described in Section 3, are Northeast, Southeast, Upper Midwest, Lower Midwest, Northwest, and Southwest. Within each region, CWTs may be assigned to one or more of 11 possible "markets":

- Metals Recovery
  - medium cost
  - low cost
- Metals Treatment
  - high cost
  - medium cost
  - low cost

- Oils Recovery
  - high cost
  - medium cost
  - low cost
- Oils Treatment
- Organics Treatment
  - high cost
  - low cost

Each of these specific types of services within a region constitutes a market. These markets were defined by examining the questionnaire data and comments on the NOA modeling assumptions. Facilities were assigned to one or more of the markets, based on their reported or estimated average cost of treatment or recovery. The quantity of waste a facility is said to accept for treatment or recovery is based on technical questionnaire data or on modeling done for the NOA, as amended based on comments. For facilities that responded to the questionnaire, commercial status is based on responses to Question O4, which asks about the quantities of wastewater accepted on a commercial and noncommercial basis. EPA assumed that the proportion reported by a facility is accurate for all subcategories and for treatment as well as recovery. For NOA facilities, EPA assumed all waste was accepted on a commercial basis.

For each commercial CWT, average (or per-gallon) baseline costs of treatment or recovery were computed based on responses to the economic section of the questionnaire. For example, the average cost of metals recovery was computed by dividing the reported cost of metals recovery by the inflow to metals recovery as reported in the technical section of the questionnaire. Reported dollar values were adjusted to 1997 dollars using the producer's price index.

D.2 MARKET STRUCTURE

After assigning facilities to markets, EPA determined the appropriate market structure as either monopoly (one CWT in the market), duopoly (two CWTs in the market), or perfect competition (three or more CWTs in the market). The market price is defined as a function of the maximum average cost within the market. For perfectly competitive markets, market price is defined as the maximum average cost across all facilities in the market. For the imperfectly competitive market structures, market price is some fraction higher than the maximum average cost across facilities in the market, reflecting the fact that under imperfect competition, facilities have market power.

D.3 FACILITY RESPONSES TO CONTROL OPTIONS DEPEND ON THE MARKET STRUCTURE

Complying with the regulation increases each affected facility's per-gallon cost of treatment in each market by the annualized per-gallon cost of the controls on that process. For example, the per-gallon cost of oils treatment is increased by the cost of implementing the controls proposed for the oils subcategory. To compute this increase in per-gallon costs, EPA first estimated the cost of controls for each subcategory, then annualized the capital and land costs and added the annualized costs to the annual operating and maintenance (O&M) and monitoring and recordkeeping (M&R) costs.

$$\text{Total Annual Cost (TAC)} = \text{(Annual O\&M and M\&R costs)} + \text{(Annualized K and Land costs)} \tag{D.1}$$

Compliance costs were adjusted from 1989 to 1995 dollars using the Construction Cost Index published in the *Engineering News Record* (1998). Costs were also adjusted to account for the tax savings due to depreciation and cost deduction provisions of the tax code. For greater detail on the controls for each subcategory and the cost adjustments made, see Section 4.

To estimate the per-gallon annual compliance costs, the TAC was then divided by the quantity of wastewater being processed in that subcategory at that facility. This per-gallon cost of compliance was added to the facility's baseline average cost to obtain its with-regulation average cost of treating that subcategory of wastewater. For example, the with-regulation average cost of oils treatment is the baseline average cost of oils treatment plus the per-gallon cost for that facility to comply with the oils subcategory guidelines or standards.

Oils and metals recovery operations are indirectly affected by the controls, because they generate wastewater. For each facility, the Agency has an estimate of the quantity of wastewater generated for each gallon of oily or metal-bearing waste accepted for recovery. If, for example, the quantity of wastewater generated by a facility's oils recovery operation is 60 percent of the quantity of oily waste accepted for recovery, the average cost of oils recovery is increased by 0.6 times the per-gallon cost of complying with the oils subcategory guidelines or standards.

Each facility compares the average with-regulation cost of performing each waste treatment or recovery operation with the additional revenue it will receive and decides whether to continue providing the waste treatment or recovery service, and if so, how much to treat. Facilities choosing to decrease the quantity of waste they treat, aggregated together, reduce the market supply of the CWT service. Market supply, interacting with market demand, results in a new, higher market price for the CWT service and a new, lower total market quantity of waste accepted at CWTs in the market for the treatment or recovery service. As the price adjusts, facilities evaluate their supply decision. The adjustments continue until a set of prices and quantities is identified that satisfies both suppliers and demanders.

The precise ways in which facilities interact with the market in adjusting to the new, higher costs of providing CWT services vary according to the market structure. Monopolies, duopolies, and competitive facilities respond somewhat differently to the costs of complying with the effluent limitations guidelines and standards. The rest of this appendix examines the adjustment to the compliance costs under each of the market structures.

D.3.1 Monopoly

Based on the with-regulation cost of treatment, monopolies identify the most profitable new price and quantity for their CWT service from the market demand for the service. Unlike perfectly competitive facilities, monopolists recognize the power they have to affect the market price. The monopolist chooses a price and output that maximize its profit. The choice of price and output depends on the behavior of customers as reflected in the curvature of the demand curve facing the monopolist.

The monopolist's profit-maximizing level of output will be where his marginal revenue equals marginal cost, or

$$MR = P\{1 + 1/n\} = MC \qquad \text{(D.2)}$$

where P is the market price and $n < 0$ is the market price elasticity of demand. Note that the monopolist will never operate where the demand curve is inelastic, because faced with inelastic demand, he can always increase his revenues by increasing his price. Thus, the optimal output will only occur in that part of the demand curve where the elasticity is greater than or equal to one.

Consider a monopolist with constant marginal costs that faces environmental regulation with a per-gallon compliance cost equal to c. The marginal cost curve shifts up by the amount of the unit compliance cost to MC = c, and the intersection of marginal revenue and marginal cost moves to the left, reflecting a reduction in output. The magnitude of the changes in market price and output will depend on the assumed shape of the demand curve. The model may specify either a linear demand curve or a constant elasticity demand curve. EPA has chosen to assume a constant elasticity demand curve of the form $q = Cp^n$. Given this demand curve, the MR = MC condition can be rewritten

$$P = (MC + c) / (1 + 1/n) \tag{D.3}$$

As indicated by that equation, a monopolist facing a constant elasticity demand curve will charge a price that is a constant markup on marginal cost given by $1/(1 + 1/n)$. Given that the demand elasticity must be elastic (greater than or equal to one in absolute value), the constant markup is greater than one so that the monopolist passes on more than the amount of the unit compliance cost to consumers. Thus, to operationalize a monopolist facing a constant elasticity demand function, the model would specify the parameters of the demand function (C and n) and determine the new market price using Eq. D.3 and the new market output by solving the market demand equation given the new market price, $q = Cp^n$.

D.3.2 Duopoly

Duopoly exists in markets having two suppliers, and each recognizes its influence over market price and chooses a level of output to maximize its profit given the output decision of the other supplier. There are a number of possible duopoly solutions, depending on the assumed behavior of suppliers as collusive, competitive, or Cournot-Nash. The Agency has chosen to employ the Cournot-Nash behavioral assumption. Under this assumption, EPA assumed that cooperation between suppliers is not achieved. Each supplier correctly evaluates the effect of its output choice on market price, and each does the best it can given the output decision of its competitor. Thus, given any output level chosen by Supplier 1, there will be a unique optimal output choice for Supplier 2. In essence, Supplier 2 behaves as a monopolist over the residual demand curve (that portion of demand not satisfied by Supplier 1). EPA constructed reaction functions for each supplier that define its optimal output choice given the selected level of output from the other supplier. The intersection of the reaction curves for each supplier is the Cournot-Nash equilibrium, since each supplier is at its optimal output level given the decision of the other.

Consider two suppliers with constant marginal costs facing per-gallon costs of complying with the CWT effluent limitations guidelines and standards equal to c_1 and c_2, respectively. The marginal cost curve for each supplier shifts up by the amount of its per-gallon compliance cost, and the intersection of MR and MC moves to the left, reflecting a reduction in output. The magnitude of the changes in market price and output will depend on the shift in the "reaction curve" of each supplier associated with the regulatory costs given a linear demand curve that is specified $p(q) = A - BQ$, where $Q = q_1 + q_2$.

In the case of duopolists facing a linear demand curve, the MR = MC condition for each supplier becomes

$$MR_1 = (A - q_2) - 2Bq_1 = MC_1 + c_1 \tag{D.4}$$

and

$$MR_2 = (A - q_1) - 2Bq_2 = MC_2 + c_2 \tag{D.5}$$

Equilibrium will be determined by the intersection of these reaction curves. Substituting Eq. D.4 into D.5 results in an equation for the optimal level of Supplier 1's output that depends on the demand parameters (A and B), its marginal cost ($MC_1 + c_1$), and the marginal cost of Supplier 2 ($MC_2 + c_2$):

$$q_1 = [A(1 - 2b) - (MC_2 + c_2) + 2B(MC_1 + c_1)] / (1 - 4B^2). \qquad \text{(D.6)}$$

Thus, to operationalize duopoly with a linear demand function, the model would specify the parameters of the demand function, A and B; determine the optimal output level of Supplier 1 using Eq. D.6 based on the unit compliance costs c_1 and c_2; determine the optimal output level of Supplier 2 using Eq. D.5, given the new optimal output level of Supplier 1 and its unit compliance cost c_2; and then determine the new market output level $(q_1 + q_2)$ and new market price $p = A - B(q_1 + q_2)$.

D.3.3 Perfect Competition

Many of the markets in the CWT economic impact analysis model have three or more suppliers and are treated as perfectly competitive. Facilities offering a CWT treatment or recovery service in a perfectly competitive market are unable to affect the market price by their actions. Thus, they maximize their profits by producing all units for which P is greater than or equal to MC + c, where MC is the baseline per-gallon cost of the treatment operation, and c is the per-gallon cost of complying with the guidelines or standards. Summing all the quantities supplied by CWTs in the market yields market supply. Market demand, characterized by a single constant price-elasticity, determines the quantity demanded at a given market price. Market price increases if quantity demanded exceeds quantity supplied or decreases if quantity supplied exceeds quantity demanded. As market price adjusts, facilities reevaluate their desired supply of CWT services, resulting in further adjustments in market supply. Adjustments continue until a price and quantity are found that satisfy both suppliers and demanders. Figure D-1 shows a competitive market with the regulatory costs included. The costs of complying with the regulation shift each facility's per-gallon cost upward, resulting in the upward shift in the supply curve. In this example, one facility has per-gallon with-regulation costs that exceed the original market price; they choose to close this CWT operation, because it is losing money. The market price adjusts upward to P_2, and

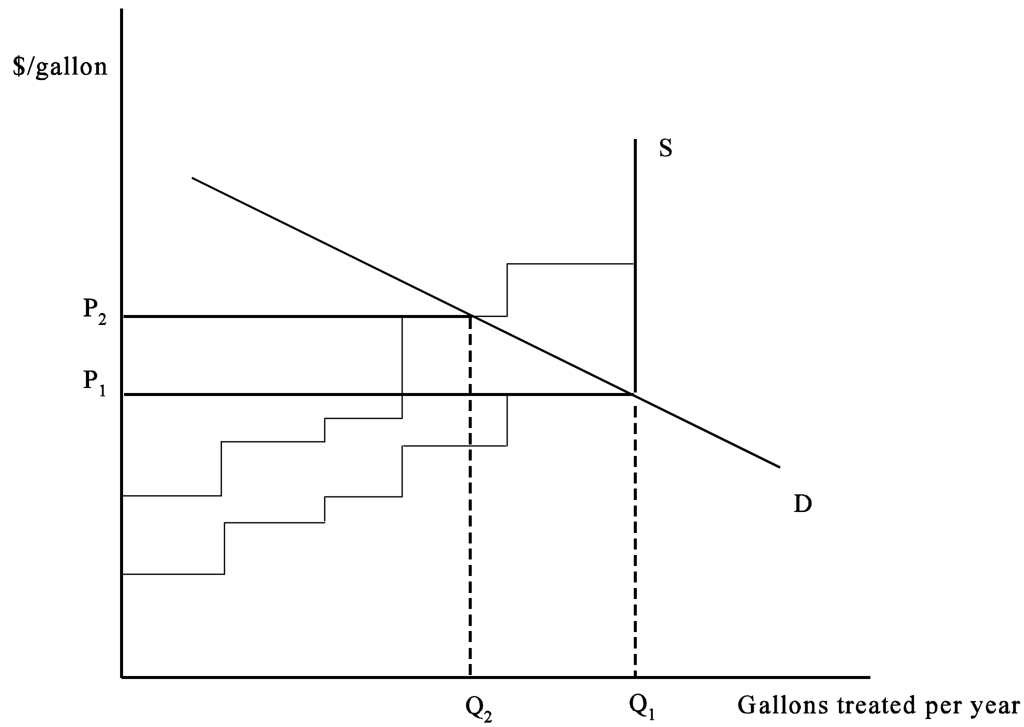

Figure D-1. Adjustment of a Perfectly Competitive Market to the Costs of Complying with the CWT Regulation

The highest cost facility shuts down this CWT operation.

total quantity treated falls to Q_2, reflecting the closure of one CWT process and a downward adjustment in the quantity treated by the next most costly CWT operation in the market.

D.4 IMPACT MEASURES ESTIMATED BY THE MODEL

As shown by the examples above, the economic impact analysis model estimates a variety of impact measures for affected facilities and markets. These measures include

- with-regulation market price,

- with regulation market quantity of waste treated,
- with-regulation facility quantity treated in each CWT operation,
- with-regulation facility revenues and costs,
- with-regulation facility employment, and
- closures of CWT operations or entire CWT facilities.

These impact measures serve as starting points for other parts of the economic analysis. For example, facility changes in employment form the basis for estimated community-wide changes in employment that form the basis of the community impacts analysis. The facility-level changes in revenues and costs can be aggregated to the owner-company level to form the basis for company-level impact measures such as changes in profit margins. Changes in market prices and quantities are used to estimate the changes in producer and consumer surplus that are a large part of the measure of social costs.

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APPENDIX E

Detailed Demand Elasticity Discussion

The own-price elasticity of demand is a model parameter that measures the responsiveness of demand for a commodity to changes in its price. As such, it is a critically important element in analyzing the extent to which costs incurred by producers are borne by them or are passed on to their customers in the form of higher market prices for the goods or services they produce. Although there are other types of demand elasticities that measure the responsiveness of demand to factors other than the price of the commodity itself, the own-price elasticity of demand is referred to as the elasticity of demand in this appendix. EPA examined the elasticity of demand for CWT services and used two different elasticities depending on the market structure. For perfectly competitive markets, EPA assumed that the elasticity of demand is -0.5. For imperfectly competitive markets, EPA assumed that the elasticity of demand was -1.5. EPA selected these elasticities as representing the most reasonable range of price-elasticity values, based on economic reasoning, after examining the economics literature and analyzing an alternative assumption. This appendix summarizes EPA's examination of the price elasticity of demand for CWT services.

E.1 THE ECONOMIC THEORY UNDERLYING THE ELASTICITY OF DEMAND FOR AN INPUT

As explained above, waste treatment is an input into the production of other goods and services, whose production also creates waste. The demand for the CWT input is derived from the demand for the other goods and services. In the market model, the change in quantity demanded of CWT service i is described as a function of the change in the market price for CWT service i and the elasticity of demand for CWT service i. Thus, the change in quantity demanded is given by

$$dQ_i = \eta_i \bullet dP_i \bullet (Q_i/P_i), \tag{E.1}$$

where

dQ_i	=	change in quantity demanded of CWT service i,
η_i	=	elasticity of demand for CWT service i,
dP_i	=	change in price of CWT service i,
Q_i	=	baseline quantity demanded of CWT service i, and
P_i	=	baseline price of CWT service i.

CWT service markets are characterized as regional markets. Based on information provided in the CWT survey, the Agency believes that most of a CWT facility's customers are located within the same state as the CWT facility or within a few adjacent states. For our market model, the continental United States was divided into six regional markets for CWT services. All the generators within each region were assumed to send their off-site waste to a CWT facility located within the region. Thus, competition for customers was assumed to occur essentially within the region, although CWT facilities located outside the region do offer a (very costly) alternative to CWT facilities within the region. The presence of these "treaters of last resort" affects the assumptions made about the elasticity of demand for CWT services.

The elasticity of demand measures the responsiveness of demand for a service to changes in its price. It is defined as the percentage change in the quantity demanded of a service divided by the percentage change in its price:

$$\eta_i = (dQ_i/Q_i) / (dP_i/P_i), \tag{E.2}$$

where the right-hand-side variables are defined as above.

Economic theory states that the elasticity of the derived demand for an input is a function of the following:

- demand elasticity for the final good it will be used to produce,
- the cost share of the input in total production cost,
- the elasticity of substitution between this input and other inputs in production, and
- the elasticity of supply of other inputs (Hicks, 1961; Hicks, 1966; and Allen, 1938).

Using Hicks' formula,

$$\eta_i = [s(n + e) + Ke(n - s)] / [n = e - K(n - s)] \qquad \text{(E.3)}$$

where

η_i	=	elasticity of demand for the CWT service i,
s	=	elasticity of substitution between CWT service i and all other inputs,
n	=	elasticity of demand for final product,
e	=	elasticity of supply of other inputs, and
K	=	cost share of CWT service i in total production cost.

In the Appendix to *The Theory of Wages*, Hicks (1966) shows that, if $n > s$, the demand for the input is less elastic the smaller its cost share (Levinson, 1997; Sigman, 1998; Smith and Sims, 1985). If the data were available, this formula could be used to actually compute the elasticity of demand for each CWT service. As noted above, however, nearly every production activity generates some waste that is managed off-site. The number of final products whose elasticity of demand (n) would need to be included is very large, and the elasticities of demand for those products vary widely. Thus, resources do not permit determination of a value for n. This makes direct computation of the elasticity of demand, η, impossible. In spite of this, the formula is useful because it identifies factors that influence the magnitude of the elasticity of derived demand. Knowledge of the general magnitude of those factors makes it possible to make an educated assumption about the magnitude of η.

The elasticity of substitution, s, between a given waste treatment service and other inputs is low but not zero. This means that waste generators do have some limited options in the way they produce their final goods or services. Some limited substitution is possible between treatment technologies for a given waste form. In addition, generators may choose to substitute out-of-region CWT services for within-region CWT services, although transportation costs would increase greatly. Further, generating facilities may substitute on-site capital, labor, and/or materials for off-site waste treatment either by choosing to manage the waste on-site or by undertaking on-site pollution prevention activities. These options are quite limited, however, so s is expected to be small, and n is likely to be larger than s.

Thus, the magnitude of η is proportional to the magnitude of K, the cost share of CWT in final goods production. Other analyses done on the CWT industry found that the cost share for waste treatment was historically very small, frequently hundredths of a percent of total production costs. Recent regulatory changes may have increased the unit cost somewhat, but it is still expected to be fairly small.

Insufficient data exist to enable the Agency to estimate the elasticity of demand for CWT services econometrically. Instead, assumptions were made about the relative magnitudes of the parameters of the Hicks equation describing the elasticity of demand for intermediate goods and services. Based on these assumptions, a reasonable assumption was made about the magnitude of the elasticity of demand for CWT services in each regional market.

Overall, the demand for CWT services is assumed to vary, depending on the structure of the CWT market. For markets with three or more CWTs (modeled as having a perfectly competitive market structure), EPA assumes the elasticity of demand to be -0.5—relatively inelastic. This demand elasticity means that, if the price of CWT services in these markets increases by 10 percent, the quantity of CWT services demanded will decrease by only 5 percent.

For CWT markets having one or two CWTs, the demand is assumed to be slightly elastic (-1.5). Demand elasticity in this range means that, when the price of CWT services increases, the quantity of CWT services demanded will decrease by slightly more, in percentage terms, than the price has increased. Because the markets being modeled are regional monopolies or duopolies, the CWT facilities possess market power and can, to an extent at least, choose the market price they charge for their services. They will always select prices that are in the elastic range of their demand curves. Elastic demand means that the percentage change in quantity exceeds the percentage change in price. Inelastic demand means that percentage change in price exceeds percentage change in quantity. A firm with market power that is operating in the inelastic range of its demand curve can increase its revenues by increasing the price it charges (Revenue = price • quantity). Thus, such a firm will always increase its price until demand becomes at least slightly elastic. In the inelastic range of the demand curve, therefore, CWT operators with market power have nothing to lose by increasing the price they charge. Only when the price rises into the elastic range of the demand curve will further increases in price decrease the firm's CWT revenues. Imperfectly competitive firms will then select the price they charge by estimating what price will yield the highest profits.

Overall, therefore, the Agency assumed markets for CWT services to be characterized by demand elasticities that range from -0.5 to -1.5. To further validate that these assumed values are reasonable, the Agency examined recent articles in the economics literature that estimate price responsiveness of similar types of services. This survey of the literature is reported in Section E.2. Finally, in Section E.3, EPA reports the result of a sensitivity analysis that assumed that CWT facilities are completely unable to increase their prices in response to a change in the cost of providing their services. This "full-cost-absorption" scenario represents the highest impacts that could be incurred by CWTs as a result of complying with the regulation. The costs of affected CWT facilities are assumed to increase by the amount of the total annualized compliance costs, while their revenues remain unchanged.

E.2 EVIDENCE FROM THE LITERATURE ON DEMAND ELASTICITIES FOR SIMILAR SERVICES

Another source of evidence about the probable range of elasticities for CWT services is articles in the economics literature that estimated the price responsiveness of demand for waste management services. At proposal, EPA had identified no economics articles that modeled markets that were similar enough to CWT services for the results to be at all applicable. During the analysis for this re-proposal, and especially after the SBREFA panel meetings, EPA conducted additional searches of the literature and identified several articles whose results might be relevant. None of the articles analyze markets that are precisely the same as the ones being affected by the CWT effluent limitations guidelines and standards. Nevertheless, they do reveal something about the influence of price on the demand for various types of waste management services and therefore indicate the expected sensitivity of demand for CWT services to changes in price. This section summarizes these articles, including a discussion of the markets being modeled and the evidence of price responsiveness of those markets.

EPA identified six articles that provide evidence about the price responsiveness of demand for waste management. Smith and Sims (1985) examine the impact of pollution charges on productivity growth in the Canadian brewing industry. Mark Eiswerth (1993) uses dynamic optimization to analyze choices between disposal options for solvent wastes. Deyle and Bretschneider (1995) examine the effect of New York's hazardous waste regulatory initiatives on the choice of disposal methods and locations. Arik Levinson (1997) examines the impact of state "NIMBY" (Not in My Back Yard) taxes on interstate transport of hazardous waste for disposal in the United States. Anna Alberini (1998) looks at the determinants of disposal choice for generators of halogenated solvents. Hilary Sigman (1998) examines the influence of variations in the cost of legal means of disposal of waste oil on the number of dumping incidents.

Smith and Sims used plant-specific data on responses to a sewer surcharge scheme, which levies extra fees for the discharge of "extra-strength" waste by indirect dischargers. The pollutants of concern in this analysis are conventional pollutants, especially BOD and TSS. The authors collected 10 years of data on shipments, labor, energy, materials, and capital stock, and environmental regulation were obtained for four breweries, two of which were subject to sewer surcharges and two of which were unregulated. The authors estimated a trans-log cost function where the factors were labor, capital, energy, and wastewater treatment. (A fixed relationship was found to exist between materials and output, so materials were omitted from estimation.) Own-price and cross-price elasticities of factor demand were computed at the sample mean, based on the empirical results. The own-price elasticity of demand for wastewater treatment was found to be -0.48. (A 1 percent increase in the price of emissions reduces emissions by 0.48 percent.)

Eiswerth examined the choice, over time, between two disposal methods for solvent waste, using a dynamic optimization model. Because the risks associated with disposing of a single type of waste can vary significantly over time depending on the disposal method, the optimal choice of disposal method depends not only on the risks at the time of disposal, but also on the variation in risk over time as natural degradation occurs. He illustrates his optimal control model by analyzing the choice between incineration and landfilling of metal-bearing solvent wastes, using accepted or assumed values for some of the critical variables. In this illustration, the optimal choice is shown to be relatively insensitive to changes in the cost differential between the two management methods. (Because this is an illustration, incorporating several simplifying assumptions, and because the dependent variable is the socially optimal quantity of incineration and land disposal, rather than the market quantity, this article's results may not be as germaine as some of the others cited here.)

Deyle and Bretschneider examine the influence of one state's hazardous waste regulatory initiatives not only on choices made within that state, but on neighboring states. They model the impact of New York policy initiatives on intra- and interstate shipments of hazardous waste to facilities where one of four different management technologies is applied: land disposal, treatment, incineration, or recycling. In the 1980s, New York enacted two initiatives aimed at encouraging generators to move up the waste management hierarchy from land disposal to treatment, recycling, or source reduction. These initiatives—a state superfund tax whose rates depended on management method and a ban on land disposal of certain waste types—also increased the cost of in-state waste management. The authors estimated 12 regression equations, examining the impact on in-state shipments to each of the four types of waste management, exports out-of-state to each of four types of waste management, and imports into New York for each of the four types of waste management. The 1985 increase in the state superfund tax had the expected effect of decreasing land disposal and increasing treatment but had no significant impact on incineration or recycling. The coefficients on exports were generally significant (as expected), because in-state generators have to pay the tax wherever they send their waste for management. The tax did, however, discourage imports from out of state, especially for land disposal. Overall, the relative increase in the cost of land disposal, compared to other, less-risky waste management methods, has the effect of shifting waste away from land disposal and discourages imports to land disposal. Insufficient data are presented in the paper to enable the computation of an elasticity.

Levinson's NBER working paper on NIMBY taxes designed to discourage in-state disposal of hazardous waste examines the effect of such taxes on interstate shipments of waste. He estimates the "tax elasticity," the percentage change in quantities of hazardous waste deposited in the jurisdiction divided by the percentage change in the hazardous waste tax rate. The estimated elasticities, computed based on average tax rates of $15 per ton, range from 0.15 to 0.26, indicating that the decision to dispose of waste within a jurisdiction is only slightly responsive to changes in the disposal tax rate. Because the tax is only a small share of the overall price of waste disposal, the author notes that these elasticities are really rather high.

Alberini's paper is an empirical study of the determinants of disposal choices for halogenated solvents. Alberini collected data on shipments of spent halogenated solvents to or from California. She also obtained information on prices charged by several hazardous waste treatment facilities for treatment of these types of waste. Finally, she collected data on the financial strength of the company owning the treatment facility, and proxied facility waste management performance by the presence of corrective action at the facility. She estimates conditional logit models of random utility for the generators, where the independent variables are the cost of disposal at a facility, a set of proxies for the likelihood that the treatment facility will become a federal or state Superfund site, variables to measure the facility's capacity to treat various types of waste, and a vector of variables for the generator's likelihood of incurring liability for cleanup at the site. When the wastes are relatively narrowly defined and the wastes are destined for recycling or transfer to another destination, the generator's choice of treatment facility is somewhat responsive to cost. However, when no treatment type is specified (and where the waste may be less homogeneous or more difficult to treat), the coefficient on treatment cost, while negative and significantly different from zero, is very small.

Finally, Sigman examines the influence of policies that increase the cost of legal treatment for waste lubricating oil on the number of illegal dumping incidents. She examines the impact of changes in the salvage value of oil and the existence of disposal bans. The imposition of a ban on legal disposal increases the cost of legal disposal and increases the number of dumping incidents. An increase in the salvage price of oil reduces the price of legal management of waste oil and decreases the number of dumping incidents. A 10 percent increase in the salvage value of oil is estimated to decrease the number of dumping incidents by 6 percent.

Together, these studies show that increases in the price or cost of waste treatment result in decreases in the quantity of waste treatment demanded. The demand for waste treatment is shown to be slightly to moderately responsive to changes in its price.

E.3 A FULL-COST ABSORBTION SIMULATION

To analyze the maximum potential impact of the CWT effluent limitations guidelines and standards on CWT facilities, EPA estimated the impacts on the profitability of facilities' CWT operations under the assumption that the CWT facilities were completely unable to pass the costs of compliance on to their customers in the form of increased prices. The increased costs of each CWT operation reduce its profitability. Under these assumptions, the with-regulation price (unchanged) is compared to the with-regulation unit cost of the operation, and operations for which with-regulation unit costs exceed the price are assumed to shut down. Again, facilities at which all affected CWT operations become unprofitable are defined as facility closures.

Tables E-1 and E-2 compare the result of this simulation with the results of the model using the assumed elasticities of demand. Table E-1 compares the number of CWT processes that are predicted to become unprofitable and shut down under each scenario. Impacts on direct and zero dischargers are unchanged. Indirect dischargers are predicted to incur 13 additional process closures if they are completely unable to pass along their costs to their customers.

TABLE E-1. PROCESS CLOSURES AT CWT FACILITIES, BY DISCHARGE STATUS[a]

	Process Closures	
Discharge Status	**Combined Regulatory Option**	**Full-Cost Absorption**
Direct dischargers	1	1
Indirect dischargers	16	29
Zero dischargers	0	0

[a] Data are scaled up to account for the entire universe of CWT facilities.

TABLE E-2. FACILITY CLOSURES OF CWT FACILITIES, BY DISCHARGE STATUS[a]

	Facility Closures	
Discharge Status	**Combined Regulatory Option**	**Full-Cost Absorption**
Direct dischargers	2	2
Indirect dischargers	13	16
Zero dischargers	0	0

[a] Data are scaled up to account for the entire universe of CWT facilities.

Table E-2 shows predicted facility closures under each scenario. Again, the impacts on direct and zero-discharging CWT facilities are predicted to be the same. Three additional indirect discharge facilities are predicted to close if they are completely unable to pass their costs along to their customers.

While the projected increase in impacts on indirect dischargers under a full-cost absorption scenario is not insignificant, it understates the costs that would be incurred by the CWT industry, even if the demand elasticity assumptions do result in greater projected price increases than would occur in reality. Thus, even if impacts on the CWT industry are more severe than projected by the model using the assumed relatively low elasticities of demand, they are expected to be economically achievable.

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